Australian Government
Australian Transport Safety Bureau

Double propeller overspeed involving Bombardier DHC-8 VH-SBV

near Weipa, Queensland | 6 December 2011

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2011-159
Final – 25 February 2013

Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Occurrence Investigation

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Double propeller overspeed involving Bombardier DHC-8, VH-SBV near Weipa, Queensland 6 December 2011

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Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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SAFETY SUMMARY

What happened

On 6 December 2011, a Bombardier DHC-8-315 aircraft, registered VH-SBV and operated by QantasLink, was on a scheduled flight from Cairns to Weipa, Queensland. The aircraft was on descent with the power levers in the flight idle position and the first officer's hand was on the power levers. When the aircraft encountered turbulence, the first officer inadvertently lifted one or both of the flight idle gate release triggers and moved the power levers below the flight idle gate. During the short time that the power levers were in the ground beta range, both propeller speeds increased uncontrollably by over 300 revolutions per minute (rpm). Realising the situation, the first officer immediately moved the power levers back above the flight idle gate and the propellers returned to the normal controlled operating rpm.

What the ATSB found

The aircraft design included features to reduce the likelihood of the power levers being moved below flight idle and into the ground beta mode during flight. However, the ATSB found that many DHC-8-100, -200 and -300 series aircraft did not have a means of preventing inadvertent or intentional movement of power levers below the flight idle gate in flight, or a means to prevent such movement resulting in a loss of propeller speed control. This design limitation has been associated with several safety occurrences.

The ATSB also concluded that the beta warning horn sounded as designed; however, the pilots were not acutely aware of the purpose of the warning horn due to a lack of previous exposure to the sound.

What has been done as a result

The aircraft manufacturer has advised that it will be releasing a Service Bulletin modification to rectify the propeller speed control issue. That bulletin will be mandated by an Airworthiness Directive (AD) from the airworthiness authority of the State of Design (Canada) to ensure that the bulletin is incorporated into all the aircraft affected by the design issue worldwide, including those in Australia. In addition, the aircraft operator has introduced a series of actions to reduce the risk of such occurrences. The ATSB has released an extract from the cockpit voice recorder with the beta warning horn and the audible rise in propeller speed to all Australian operators of the aircraft type and it is also available on the ATSB website in an effort to increase awareness of the issue.

Safety message

Until appropriate modifications are made to DHC-8 aircraft, pilots and operators of DHC-8-100, -200 and -300 series aircraft should familiarise themselves with the circumstances surrounding this occurrence and take the appropriate steps to minimise the possibility of propeller overspeed due to ground beta selection in flight.

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Prepared By

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608 Australia
www.atsb.gov.au

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB’s investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: the ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of flight

At about 1830 Eastern Standard Time[1] on 6 December 2011, a Bombardier DHC-8-315 aircraft, registered VH-SBV, operated by QantasLink, was on a scheduled flight from Cairns to Weipa, Queensland. The first officer was the pilot flying. The pilots reported that, during descent, the aircraft entered a layer of cumulus cloud as it descended through about 12,000 ft. At that time, the speed was reduced from 200 to 190 kts (the turbulence penetration speed[2]) and the engine condition levers were set for a propeller speed of 900 revolutions per minute (rpm).

The first officer reported that he reduced engine power to flight idle and kept his left hand on the power levers. Shortly after the aircraft entered cloud, there were a few ‘small bumps’ associated with the turbulence. A few seconds later, the aircraft encountered a strong updraft followed by a downdraft, which caused the first officer to rise out of his seat and put upward pressure on his seat restraints. He recalled that, during this period, he inadvertently moved the power levers below the flight idle gate and into ground beta mode.[3] At the same time, he heard the beta warning horn sound and increasing propeller noise. Realising the situation, he immediately moved the power levers forward of the flight idle gate.

The captain recalled that he initially thought that the warning horn was the sound of the autopilot disengaging, but realised that was not the case as soon as he heard the propeller noise increase. He asked the first officer what had happened and the first officer said that the power levers had moved behind the flight idle gate after his fingers had tripped the flight idle gate release triggers due to the turbulence.

The crew reported that there were no abnormal engine indications and the flight proceeded normally to Weipa. Subsequent maintenance checks after the flight did not reveal any engine or propeller system damage.

Pilot information

First officer

The first officer was the pilot flying at the time of the incident. He held a Commercial Pilot (Aeroplane) Licence with about 500 hours experience on the aircraft type and about 2,430 hours total flight experience. He reported that he was well rested at the time of the incident.

[1] Eastern Standard Time (EST) was Coordinated Universal Time (UTC) +10 hours.

[2] Turbulence penetration speed is the maximum recommended speed at which the aircraft is to enter turbulence.

[3] Ground beta is a control mode used by the pilot to manually control the pitch of the propeller blades during ground operations. Propeller speed governing is inhibited during ground beta mode selection; therefore the use of ground beta mode in the air was prohibited.

Captain

The aircraft captain held an Air Transport Pilot (Aeroplane) Licence, with about 2,100 hours experience on the aircraft type, with 1,200 of those as pilot in command. He had 4,000 hours total flight experience.

Aircraft information

The Bombardier DHC-8-315 is a high-wing, pressurised aircraft with a seating capacity of 50 passengers (Figure 1). The aircraft is powered by two Pratt and Whitney PW123 turboprop engines, driving two Hamilton Sundstrand four-blade propellers. The aircraft was delivered new from the manufacturer to the operator and registered in Australia as VH-SBV in 2003.

Figure 1: Exemplar picture of a DHC-8-315 aircraft

Propeller speed control systems

Power and condition levers

The aircraft type is equipped with systems to allow the flight crew to manage propeller speed:

- **Engine condition levers**. The condition levers control propeller speed between 900 (MIN) and 1,200 rpm (MAX), and allow engine starting, propeller feathering[4] and engine shutdown (FUEL OFF). In Figure 2, the condition levers are in the FUEL OFF position.
- **Engine power levers**. In flight mode, the power levers control engine speed as required between flight idle and take-off power. In ground beta mode, the power levers control propeller pitch directly for slowing the aircraft after landing and ground manoeuvring. In Figure 2, the power levers are in the take-off position.

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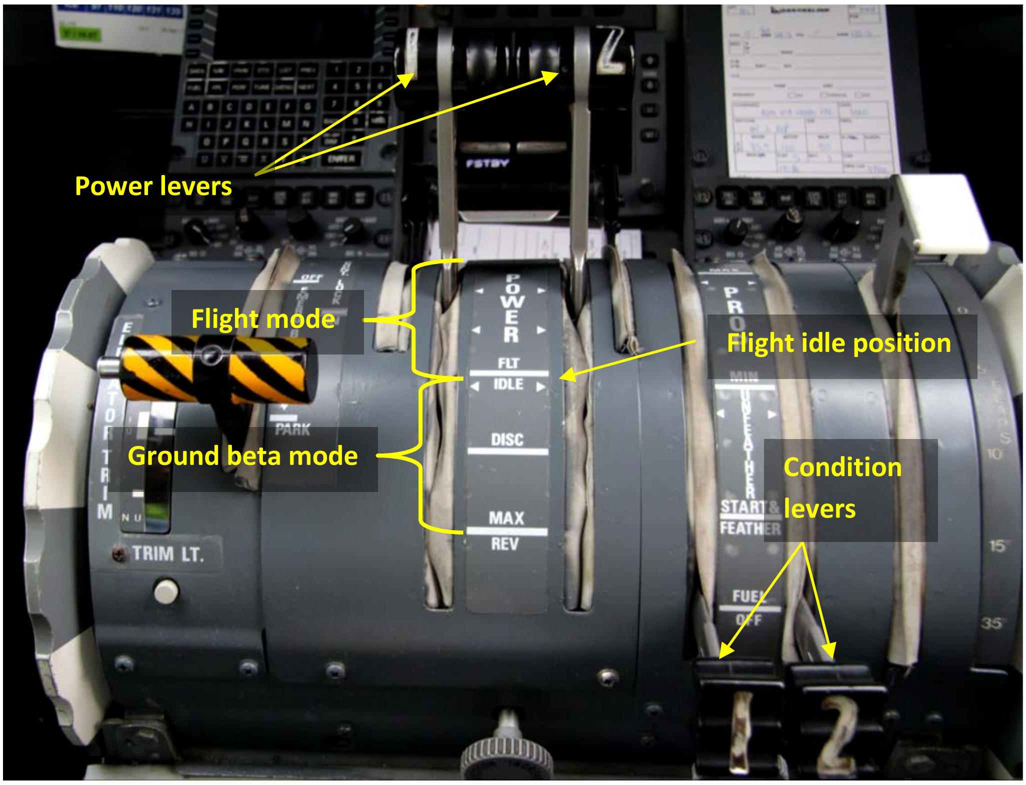
4 The term used to describe rotating the propeller blades to an edge-on angle to the airflow that minimises aircraft drag following an engine failure or shutdown in flight.

Figure 2: Exemplar picture of engine control quadrant



Propeller system components and description

In normal flight operation between flight idle and take-off power, the propeller control unit (PCU) controls and maintains the propeller speed between 900 rpm and 1,200 rpm through its governor and control inputs from the condition levers. The PCU maintains the propeller speed by increasing the pitch angle on the propeller blades to decrease propeller speed or conversely the PCU will decrease the pitch angle on the blades to increase propeller speed.

An overspeed governor is fitted to the engines for propeller overspeed protection. In the event that the PCU does not govern the propeller below its maximum speed of 1,200 rpm, the overspeed governor will sense the propeller overspeed condition at 103% (1,236 rpm) and increase the blade angle to reduce the propeller speed. At about 109% (1,309 rpm) the overspeed governor will also reduce the propeller speed by reducing fuel flow to the engine.

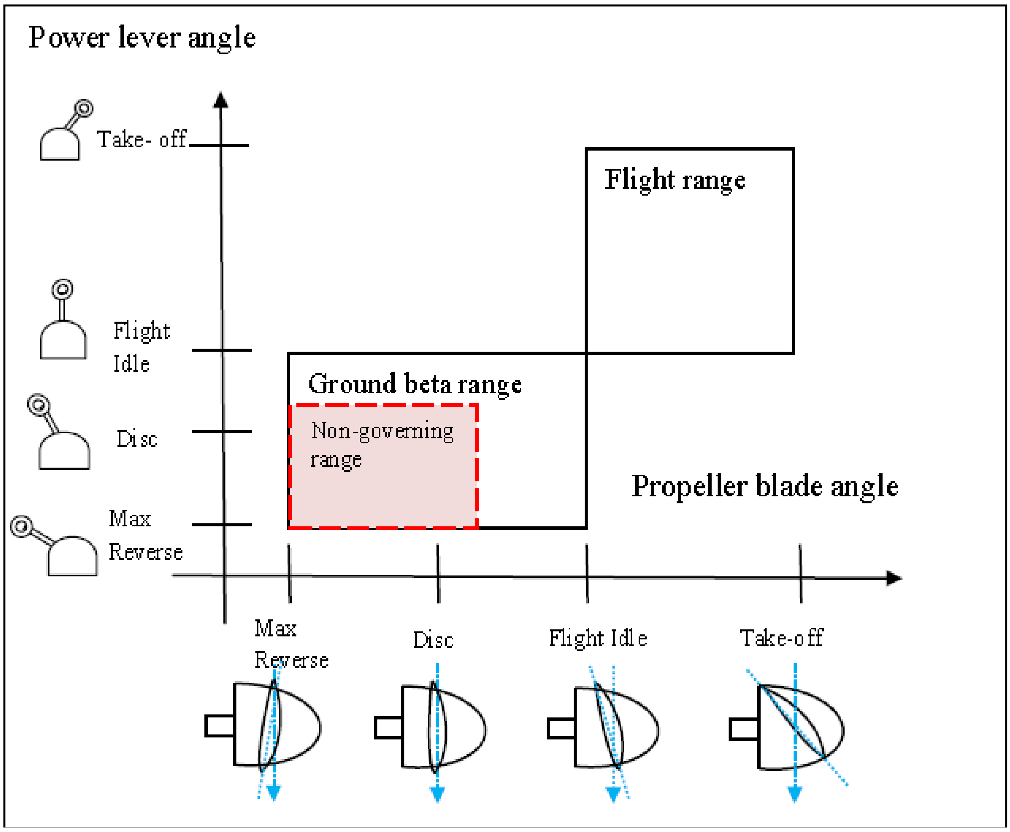
The system also incorporates a beta backup system that increases the propeller blade angle if it senses the blade angle is below the flight idle setting with the power levers above the flight idle gate.

When the power levers are moved to an angle of 13° below the flight idle gate, the governing function of the propeller control unit and the overspeed governor are inhibited and the beta backup system is deactivated. This is an intended design feature to allow the power levers to control the propeller pitch directly during ground operations. The propeller does not require speed governing during ground operations as there is insufficient airspeed to drive the propeller to an overspeed condition.

In summary, propeller overspeed is prevented by three systems, provided the power levers are maintained above the flight idle gate in flight. If the power levers are moved below flight idle in flight, the propeller speed is no longer controlled by the propeller control systems, leaving the propellers susceptible to an overspeed condition that could rapidly lead to engine damage and, in the worst case, engine failure.

Figure 3 shows the relationship between power lever angle and propeller blade pitch angle and the area where propeller speed is not governed.

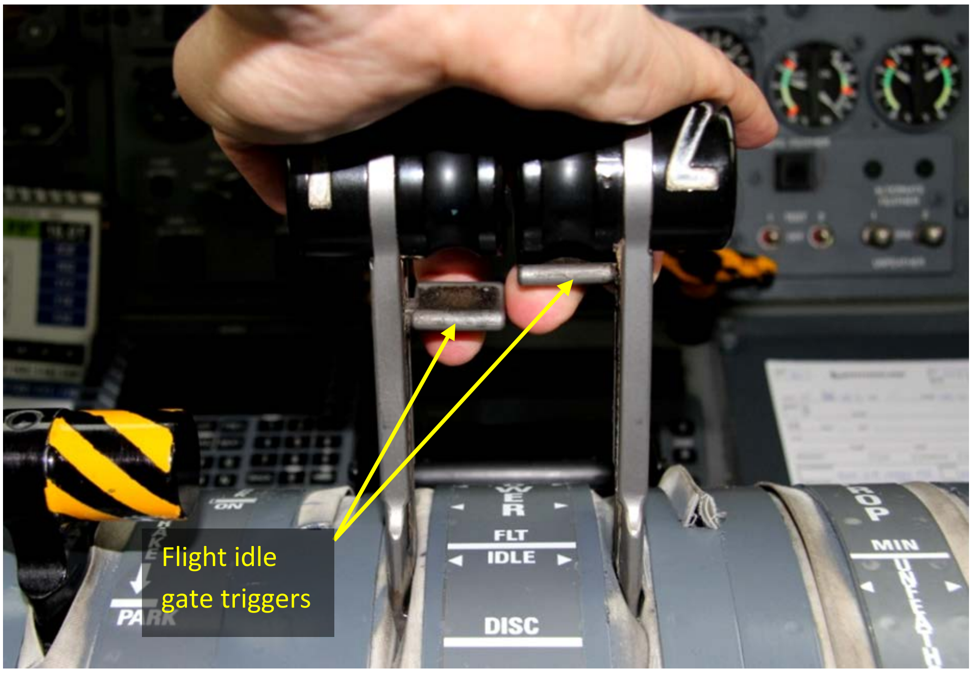
Figure 3: Power lever angle and propeller blade pitch angle



Flight idle gate and release triggers

The power lever quadrant includes a mechanical stop, called the flight idle gate, to assist with preventing movement of the power levers below flight idle in flight. Each power lever grip incorporates a flight idle gate release trigger that has to be lifted in order for the power levers to bypass the flight idle gate to enter ground beta mode. Testing conducted by the Australian Transport Safety Bureau (ATSB) on an exemplar aircraft confirmed that only one of the triggers had to be lifted about 6 mm to enable both power levers to bypass the flight idle gate and move into the ground beta range. Figure 4 shows the power levers with one of the triggers lifted to the height required to bypass the gate.

Figure 4: Power levers showing flight idle gate triggers



The first officer could not recall precisely how he had been gripping the power levers at the time of the occurrence. His normal practice was to rest the palm of his hand on top of the levers and he believed that was the case on this occasion. He thought that his fingers were angled downwards, with the middle finger between the levers. He could not recall if he had any backwards pressure on the levers but felt that his hand moved upwards during turbulence and that one of his fingers had lifted one of the triggers.

The ATSB conducted testing on the same aircraft type while alternatively seated on the captain's and first officer's side, with the seat correctly adjusted to the normal flight position. With the hand placed with the palm on top of the power levers there was a noted tendency for the middle two fingers to touch the flight idle gate release triggers when moving the power levers rearward.

Beta warning horn

The beta warning horn provides an audible warning when the flight idle gate release triggers are lifted in flight. At any power lever setting, raising either release trigger during flight will activate the horn. The horn can be silenced by releasing the trigger(s) with the power levers selected above the flight idle gate.

Flight manual warning

Section 2.5.8 of the *Aircraft Flight Manual* stated:

> In-flight operation of the power levers aft of the FLT IDLE gate is prohibited. Failure to observe this limitation will cause propeller overspeed, possible engine failure and may result in loss of control.

Recorded information

Cockpit voice recorder

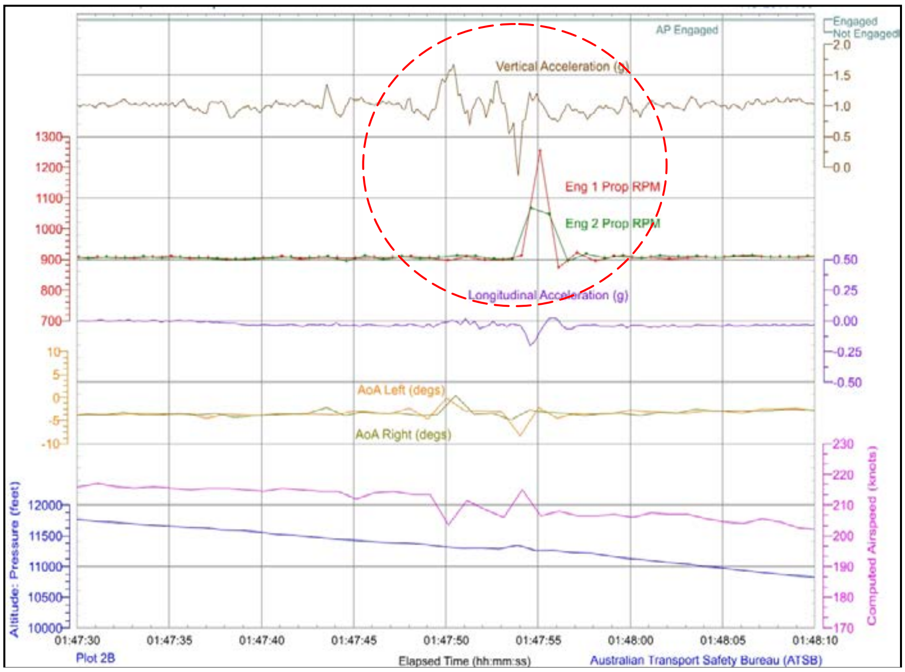
Examination of the cockpit voice recorder (CVR) data revealed that the beta warning horn was audible for about 0.8 seconds and corresponded with an audible rise in propeller rpm. The sounds of the propellers recorded on the CVR indicated that the maximum speeds were 1,275 ± 15 rpm and 1,215 ± 15 rpm.

Digital flight data recorder

Examination of the data from the aircraft's DFDR showed that, at an altitude of 11,300 ft and at a computed airspeed of 215 kts, there was a period of approximately 3 seconds during which the rpm of both propellers increased above the set 900 rpm. The maximum recorded rpm for each propeller was 1,253 rpm for the left propeller and 1,067 rpm for the right propeller (Figure 5).[5]

Prior to that period, there were fluctuations in computed airspeed, angle of attack and vertical acceleration which were consistent with the aircraft operating in turbulence. There was a period of positive vertical acceleration, consistent with an updraft, which commenced about 4 seconds before the propeller RPM increased. This was followed by a rapid decrease in vertical acceleration from +1.5 g to -0.1 g[6] just before the propeller speed increases occurred. There was a decrease in longitudinal acceleration coincident with the propeller rpm increases, due to an increase in propeller drag as the blades moved to a finer angle.

Figure 5: DFDR data showing propeller speed increase



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[5] The DFDR propeller rpm sample rate was once per second so the most accurate capture of propeller rpm would be from the CVR.

[6] G load is the nominal value for acceleration. In flight g load values represent the combined effects of flight manoeuvring loads and turbulence. This can be a positive or negative value.

Aircraft certification and modification history

Initial certification requirements

The first DHC-8 model (DHC-8-100) was certified in Canada and the United States (US) in 1984. The US Federal Aviation Regulations (FARs) at the time stated:

> 25.1155 Reverse thrust and propeller pitch settings below the flight regime.
>
> Each control for reverse thrust and for propeller pitch settings below the flight regime must have means to prevent its inadvertent operation. The means must have a positive lock or stop at the flight idle position and must require a separate and distinct operation by the crew to displace the control from the flight regime (forward thrust regime for turbojet powered airplanes).

The Canadian Aviation Regulations (CARs) did not require any additional means to minimise the likelihood of flight crews moving the power levers below the flight idle gate in flight.

Modified flight idle gate

The DHC-8-102 was certified in Europe and the United Kingdom (UK) in the mid-1980s, with the certifying authorities using the US FARs as the certification basis.

During the certification process, the UK Civil Aviation Authority (CAA) introduced an additional design requirement that mechanically prevented the flight idle gate release triggers from being effective unless both power levers were at the flight idle position. Although the modification reduced the likelihood of flight crew moving the power levers below the flight idle gate, it did not prevent this from occurring.

Flight idle gates modified to the requirements of the UK CAA were only required for DHC-8 aircraft registered in the UK and were not required to be fitted to aircraft certified in other countries. VH-SBV was not fitted with the modified flight idle gate as it was not a requirement in Canada, where it was manufactured, nor in Australia.

Beta lockout system

Following a series of accidents and incidents in the 1980s and early 1990s involving intentional and inadvertent selection of beta mode in flight in other types of turboprop aircraft, the US National Transportation Safety Board (NTSB) issued several recommendations to the US Federal Aviation Administration (FAA). These recommendations included:

> NTSB Recommendation #A-94-062: The NTSB recommends that the Federal Aviation Administration: revise Title 14 Code of Federal Regulations, Parts 25.1155 and 23.1155 to require a positive means to prevent operation of the propeller in the beta mode while in flight, unless the airplane is certified for such use.

> NTSB Recommendation #A-94-063: The NTSB recommends that the Federal Aviation Administration: Review all other turbopropeller airplane designs to determine whether in-flight engine operation in the beta range should be prohibited. Issue appropriate airworthiness directives applicable to those airplanes to install a system to prevent movement of power levers into the beta range, and require appropriate warnings in airplane operating manuals and on cockpit placards to warn pilots not to move power levers into the beta range in flight, unless the airplane is certificated for such use.

As a result of the NTSB recommendations, the FAA issued requirements for many aircraft flight manuals to be modified to include specific warnings to prohibit the use of beta mode in flight. It also introduced a series of airworthiness directives (ADs) for lockout systems on specific types of turboprop aircraft to prevent power levers from being moved into the beta range in flight. The modifications were applied to all affected aircraft that operated within the US. For many of the aircraft types, the changes were also adopted by other countries, including Australia.

On 1 March 2000, the FAA issued AD 2000-02-13, which mandated, within 2 years, the installation of a system that prevented the positioning of the power levers below the flight idle stop in flight on all DHC-8-100, -200 and -300 series aircraft that operated within the US.

The aircraft manufacturer designed a beta lockout system as a means of compliance with the AD. Although the system did not prevent flight crews from moving the power levers below the flight idle gate in flight, it prevented such an action from resulting in a propeller overspeed. The manufacturer issued service bulletin 8-76-24 on 9 January 2002, and the FAA subsequently approved the manufacturer's beta lockout system and mandated its fitment to all DHC-8 aircraft operating within the US.

Transport Canada, the airworthiness authority in the State of Design, did not adopt the FAA AD or mandate compliance with the manufacturer's service bulletin. Consequently, the beta lockout system was not mandated in other countries, including Australia.[7] The system was subsequently mandated by Papua New Guinea in October 2011 following a DHC-8-100 accident in that country (see below).

The beta lockout system was not fitted or required to be fitted to VH-SBV.

Beta warning horn

The aircraft manufacturer introduced a service bulletin modification in 2001 which recommended the installation of a beta warning horn. Transport Canada mandated the fitment of the modification with an AD and this was subsequently adopted by other airworthiness authorities including Australia. It was fitted to VH-SBV.

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7 Under Civil Aviation Safety Regulation 39, the Civil Aviation Safety Authority (CASA) automatically mandates the AD requirements of the regulatory authorities from the State of Design. This does not prevent CASA or regulatory authorities in other countries from placing their own regulatory requirements on aircraft types if they identify a need to do so.

DHC-8-400 series aircraft

The DHC-8-400 series aircraft were first certified in Canada in 1999 and the US in 2000. The model is designed with a different type of propeller control system to previous models, which provides additional protection for the consequences of moving the power levers below the flight idle gate and into the ground beta range in flight. All -400 series aircraft also have the UK CAA gate modification fitted, which prevents raising the flight idle gate release triggers unless the power levers are at flight idle.

Modified certification requirements

The relevant European certification requirement has historically been the same as FAR 25.1155. In 2003, the European Certification Standard (CS) 25.1155 included the following:

> Each control for selecting propeller pitch settings below the flight regime (reverse thrust for turbo-jet powered aeroplanes) must have the following:
>
> (a) A positive lock or stop which requires a separate and distinct operation by the flight crew to displace the control from the flight regime (forward thrust regime for turbo-jet powered aeroplanes), and it must only be possible to make this separate and distinct operation once the control has reached the flight idle position.
>
> (b) A means to prevent both inadvertent and intentional selection or activation of propeller pitch settings below the flight regime (reverse thrust for turbo-jet powered aeroplanes) when out of the approved in-flight operating envelope for that function, and override of that means is prohibited…

The Acceptable Means of Compliance section relating to CS 25.1309 stated:

> In-service experience during the late 1980s and 1990s of some turbo-propeller powered transport category airplanes, has shown that intentional or inadvertent in-flight operation of the propeller control systems below flight idle has produced two types of hazardous, and in some cases, catastrophic conditions:
>
> (i) Permanent engine damage and total loss of thrust on all engines when the propellers that were operating below the flight regime drove the engines to over-speed, and;
>
> (ii) Loss of airplane control because at least one propeller operated below the flight regime during flight creating asymmetric control conditions.
>
> As a result of this unsatisfactory service experience, in-flight beta lockout systems were retroactively required (via Airworthiness Directives) on several transport category turboprop airplanes. These beta lockout systems were required only after it was determined that increased crew training, installation of cockpit placards warning crews not to use beta in flight, and stronger wording in AFM warnings and limitations did not preclude additional in-flight beta events.

> In addition to the continued airworthiness issues noted above, the FAA also recognized the need to update the FAR requirement to require some form of design improvements for new airplanes. .. Until the rule changes noted above are complete, the FAA is using the no unsafe feature or characteristic provisions of 21.21(b)(2) to require installation of beta lockout systems on new transport category turbo-propeller powered airplanes.

The enhanced certification approach in Europe and the US did not result in any requirements to modify existing aircraft.

Australian DHC-8 fleet

As of March 2012, there were 57 DHC-8-100, -200 and -300 series aircraft registered in Australia. Some of the aircraft were acquired second-hand from the US or UK and had a beta lockout system or UK CAA gate previously installed as required by the respective country's airworthiness requirements. The ATSB contacted the DHC-8 operators and determined that:

- five aircraft were fitted with the beta lockout system
- four aircraft were fitted with the UK CAA gate
- 48 aircraft were not fitted with either system
- all 57 aircraft were fitted with a beta warning horn.

At the time of this occurrence, there were 52 aircraft in Australia that were not protected against the consequences of a flight crew inadvertently or intentionally moving the power levers below flight idle in flight.

VH-SBV was delivered new from the manufacturer in Canada to the operator in 1983 and had only ever been registered in Australia; therefore the aircraft was not required to have and did not have a beta lockout system or UK CAA gate modification fitted.

Related occurrences

Australian-registered aircraft

During the investigation, information was received concerning two other events involving activation of below flight idle in flight in Australian registered DHC-8 aircraft within the previous 2 years. Both events involved the inadvertent movement of the power levers below the flight idle gate in flight. One of the aircraft was one of the five in Australia that was fitted with the beta lockout system The other aircraft was a DHC-8-400, which had a significantly different propeller system control that prevented propeller overspeed.

Although both aircraft had propeller overspeed prevention systems in the event of the power levers being moved below flight idle in flight, they had an identical power lever quadrant and flight idle gate system. The events therefore indicate the potential for aircraft without such overspeed prevention systems to be operated below flight idle with undesirable consequences.

10 March 2010, DHC-8-400

During descent, the pilot flying reduced power when he noticed the speed increasing. That action did not have the desired effect, so he disengaged the autopilot and pitched the nose of the aircraft up. He subsequently re-engaged the autopilot after which the nose pitched down and the speed increased rapidly. The pilot again disengaged the autopilot and 'grabbed the power levers to reduce power'. As he did so, he inadvertently lifted the flight idle gate release triggers and moved the power levers into the disc (ground beta) range. He immediately realised what had occurred and advanced the levers forward of the flight idle detent. There was no damage to the aircraft.

2 November 2011, DHC-8-100

The crew reported that while on the downwind leg in the circuit prior to landing, the Master Caution Light illuminated, along with the No.1 and No. 2 ENG MANUAL caution lights, indicating that the engine electronic control units (ECUs) had reverted to manual control. According to the aircraft manufacturer, there is a latched 'tell-tale' that reverts the engine controls to manual, with associated caution lights, which can only be reset on the ground. This event required the circuit breaker to be reset before the ECUs would operate normally, indicating that the flight idle gate release triggers had been lifted in flight and the power levers had been selected to the rear of the flight idle position. The operator's investigation determined that the pilot flying may have inadvertently and momentarily lifted the triggers during turbulence.

A post-incident engineering inspection revealed that the beta warning horn was unserviceable at the time of the event. The aircraft was previously registered in the US where it had a beta lockout system fitted.

Overseas-registered DHC-8 aircraft

1 April 1996, DHC-8-100, Canada

During descent at an airspeed of 245 kts indicated airspeed, both propellers simultaneously exceeded the maximum speed by more than 25%. The overspeed condition resulted in the failure of the right engine's power turbine section. It is believed that one of the pilots moved both power levers below the flight idle gate in flight during turbulence.

28 May 1996, DHC-8-300, Canada

The pilot reported that on descent he pulled the power levers into ground beta range and the propellers simultaneously exceeded their maximum rpm. Immediate reselection of the power levers above flight idle resulted in propeller speed governing recovery.

21 February 2006, DHC-8-103, Norway

The Accident Investigation Board Norway (AIBN) concluded that the captain inadvertently moved both power levers below the flight idle gate in flight during severe turbulence. The aircraft experienced a double propeller overspeed and subsequently one engine failed. [8]

In February 2007, the AIBN issued an interim safety recommendation to the aircraft manufacturer that stated that 'All [DHC-8] models that can be reversed unintentionally during pull back of power levers should be modified in such a manner that dangerous inadvertent airborne reversing is unlikely to happen…'. The aircraft manufacturer and Transport Canada did not adopt the recommendation. The manufacturer advised that they had 'thoroughly reviewed the existing power lever flight idle gate design and find that inadvertent airborne reversing is unlikely to occur…'.

The AIBN released its final report in June 2012 and issued the following recommendation:

> The Accident Investigation Board Norway recommends that Transport Canada and EASA require the type certificate holder (Bombardier) to introduce measures to prevent propeller overspeed during unintended management of Power Levers.

7 October 2008, DHC-8-101, Chad

During descent, the aircraft exceeded its maximum airspeed, which was followed immediately by a right propeller overspeed and in-flight engine shutdown. The aircraft manufacturer advised that this event was likely to have been as a result of the crew moving the power levers below the flight idle gate in flight.

13 October 2011, DHC-8-103, Papua New Guinea

During descent, the aircraft had a double propeller overspeed and in-flight engine shutdown. Both propellers exceeded the maximum rpm by 60%. A forced landing was carried out and the aircraft was destroyed. Twenty-eight of the 32 occupants were fatally injured. The accident is being investigated by the Papua New Guinea (PNG) Accident Investigation Commission (AIC).[9]

In response to the accident, the PNG Civil Aviation Safety Authority (PNG CASA) issued airworthiness directive PNG AD/DHC8/22 on 28 October 2011. The AD mandated the immediate operational testing of beta warning horns, the beta back-up system and the overspeed governor. It also mandated the fitment of a placard in a prominent location on the instrument panel of the cockpit that stated:

> Positioning of the power levers below flight idle stop during flight is prohibited. Such action may lead to loss of aircraft control, or may result in an engine overspeed condition and consequent loss of engine power.

On 4 November 2011, PNG CASA issued AD/DHC8/22 Issue 2, which also required the mandatory installation of the beta lockout system in accordance with the FAA AD within 120 days of the issue date.

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[8] The AIBN report is available at www.aibn.no/Aviation/Reports/2012-05-eng

[9] A copy of the AIC's preliminary report is available on the ATSB web site at: http://www.atsb.gov.au/publications/investigation_reports/2011/aair/ae-2011-132.aspx

On 9 November 2011, the aircraft manufacturer issued All Operator Message No. 971. The message warned that the movement of the power levers below the flight idle gate in flight was prohibited. The message also stated:

> When the POWER Levers are moved aft of the FLIGHT IDLE gate in-flight, the Propeller Governor, Propeller Overspeed Governor and the BETA Backup logic protection are all inhibited and Propeller speed control is no longer available. In this condition the propeller(s) would be driven uncontrollably toward a reverse pitch condition resulting in an overspeeding propeller and substantial engine damage leading to possible engine failure.

Related occurrences involving other aircraft types

Since about 1987, other transport-category turboprop aircraft types, equipped with similar engines and propeller systems, have been involved in propeller overspeed events, some of which led to loss of control of the aircraft. To date, all of those manufacturers have issued mandatory service bulletins or incorporated modifications to prevent ground beta activation during flight. For details of those events refer to Appendix A.

The ATSB determined that, with the exception of the DHC-8, all of the other transport-category turboprop aircraft used in Australia were fitted with a system designed to prevent propeller overspeed events arising from power levers being moved to below flight idle in flight.

DHC-8 flight crew training

The captain and first officer of VH-SBV reported that they were very aware of the risks of propeller overspeed if the power levers were moved below the flight idle gate during flight, and that such an action was prohibited. The first officer noted that the DHC-8 accident on 13 October 2011 in PNG, and the subsequent Safety Alert Notice issued by the aircraft manufacturer and distributed by the operator, had placed the issue fresh in his mind.

Both of the flight crew stated that they had not received any training with regard to hand or finger positioning on the power levers. The captain stated that he had reviewed his method of gripping the power levers after receiving the Safety Alert Notice following the PNG accident, but considered that it was appropriate in terms of maintaining clearance from the flight idle gate release triggers.

The captain and first officer advised that they had learned about the warning system during endorsement training but had never heard the sound demonstrated. They reported that they had heard the sound during simulator training, as the simulator was being ‘repositioned’, but the sound had never been referred to as the ‘beta warning’.

The operator of VH-SBV provided the following information regarding audible beta warnings and hand position:

- Pilots received instruction regarding the propeller control system and its operation, including the operation of the beta warning system, during endorsement training but they did not hear an example of the audible warning.

- There were no references in any of the operator’s publications regarding hand or finger positioning during power lever manipulation and there was no training given in that regard. The operator was not aware of any problems in this area.

The ATSB determined that the information provided by the operator of VH-SBV was consistent with the training provided by other Australian operators of DHC-8 aircraft who were contacted.

ANALYSIS

The occurrence

During the occurrence, the DHC-8-315 aircraft was on descent with the power levers in the flight idle position. The first officer’s hand was on the power levers. When the aircraft encountered turbulence, the first officer’s fingers inadvertently lifted one or both of the flight idle gate release triggers and moved the power levers below the flight idle gate, which resulted in a double propeller overspeed event.

This type of occurrence has a significant potential to result in serious consequences. If the power levers are moved below the flight idle gate during flight, the propeller speed control and overspeed protection systems are inhibited. When combined with high airspeeds, the propellers will be driven by the airflow much like a windmill and, depending on aircraft speed, could result in the propeller rpm limits being exceeded. If not detected and recovered very quickly, this situation can lead to one or both engines failing. In this case, the first officer quickly realised the situation and moved the power levers forward of the flight idle gate before engine damage occurred.

Propeller overspeed protection

At the time of the occurrence, a significant number of DHC-8-100, -200 and -300 aircraft in Australia and other countries outside the United States and Papua New Guinea did not have a beta lockout system installed to prevent propeller overspeed in the advent of below flight idle selection in flight, nor were they required to.

Power lever and propeller system design

The aircraft design included features to reduce the likelihood of the inadvertent movement of the power levers below flight idle and into the ground beta mode during flight. These included the flight idle gate, which required a separate action (lifting the release triggers) before being able to move the levers past the gate.

Although such a feature significantly reduces the likelihood of inadvertent action, it does not prevent it. There are multiple ways in which a pilot could inadvertently bypass the gate. For example, as with this occurrence and some others, during turbulence it is likely that pilots will grip the power levers more tightly. As it is natural for a pilot’s fingers to be touching the release triggers when holding the power lever, it is therefore likely that a pilot will move the triggers in some cases during turbulence.

In addition, pilots use the release triggers during each landing to move the power levers into the ground beta range in order to slow the aircraft down. It is a routine, skill-based action. In some cases, particularly when under high workload or distraction, skill-based actions will be confused with other actions, particularly those that share similar features.[10] Such errors are commonly known as ‘slips’. It is

[10] Reason, J 1990, *Human Error*, Cambridge University Press.

conceivable that occasionally, under unusual flight conditions or workload or distraction, the action of slowing an aircraft down in flight, by pulling back on the power levers, could be confused with the action of slowing the aircraft down on the ground.

The manufacturer had installed a beta warning horn to alert pilots when the flight idle gate release triggers had been lifted. Audible warnings can be very effective at attracting attention, although experience has shown that they are not always heard or comprehended in sufficient time to make an effective response, particularly in times of high workload or distraction.[11] The potential effectiveness of the DHC-8 beta warning in achieving a rapid response was further limited by the fact that pilots had not had the horn demonstrated to them during training.

In summary, the DHC-8-100, -200, -300 power lever design had features that significantly reduced the likelihood that flight crew would pull the power levers below flight idle in flight. However, there have been several documented occurrences where flight crews have bypassed the flight idle gate during flight. Although the likelihood of any such occurrence on each flight is very low, the potential for any such event to result in engine damage and a more adverse outcome is significant. No other transport category turboprop aircraft in use in Australia were associated with a similar design issue.

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11 Rehman, N 1995, *Flightdeck crew alerting issues: An aviation Safety Reporting System analysis*, US Department of Transportation / Federal Aviation Administration Report DOT/FAA/CT-TN94/18.

FINDINGS

Context

From the evidence available, the following findings are made with respect to the double propeller overspeed involving the Bombardier DHC-8-315 aircraft, registered VH-SBV that occurred near Weipa, Queensland on 6 December 2011. The findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The pilot flying inadvertently lifted the flight idle gate release triggers and moved the power levers below the flight idle gate during turbulence, which led to ground beta operation in flight and loss of propeller speed control.
- A significant number of DHC-8-100, -200 and -300 series aircraft did not have a means of preventing inadvertent or intentional movement of power levers below the flight idle gate in flight, or a means to prevent such movement resulting in a loss of propeller speed control. *[Significant safety issue]*

Other safety factors

- The operator's DHC-8 pilots had not had the beta warning horn demonstrated to them during their training. A similar situation applied to other Australian operators. *[Minor safety issue]*

Other key findings

- The first officer realised that he had inadvertently selected the power levers to below flight idle and immediately rectified the situation, avoiding damage to the propellers and engines.
- The investigation identified several incidents where a DHC-8 pilot inadvertently moved one or both power levers behind the flight idle gate in flight that led to a loss of propeller speed control. Those events collectively indicate a systemic design issue within the aircraft's propeller control system.
- Other transport category aircraft types in use in Australia have systems that either mechanically prevent in-flight selection of the power levers below flight idle in flight or prevent propeller overspeed when the power levers are in the ground beta range.
- The US Federal Aviation Administration and the Civil Aviation Safety Authority of Papua New Guinea had mandated the fitment of a system that prevents DHC-8-100, -200 and -300 series aircraft propeller overspeed if the power levers are selected into the ground beta range while in flight.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Bombardier Inc. and Transport Canada

Power lever design issue

Significant safety issue

A significant number of DHC-8-100, -200 and -300 series aircraft did not have a means of preventing inadvertent or intentional movement of power levers below the flight idle gate in flight, or a means to prevent such movement resulting in a loss of propeller speed control.

Action taken by Bombardier Inc. & Transport Canada

On 19 June 2012 the manufacturer issued an All Operator Message No. 994, which stated that:

> Despite incorporation of the beta warning horn modification, incidents continue to occur in which the power levers are selected aft of the flight idle gate, into the beta range during flight. As a result, Transport Canada has indicated their intention to issue an Airworthiness Directive to mandate incorporation of a beta lockout modification for all aircraft that do not already have one installed. Bombardier has conducted an internal review of the existing engineering for the FAA approved installation and will be revising the engineering to cover all aircraft configurations in service and to introduce modification kits.

On 13 September 2012 the manufacturer issued Service Bulletin (SB) 8-11-115, which recommended the fitment of a warning placard in the cockpit that stated:

> Positioning of the power levers below the flight idle stop during flight is prohibited. Such positioning may lead to loss of airplane control, or may result in an engine overspeed condition and consequent loss of engine power.

That SB was mandated by Transport Canada AD CF-2012-33 for fitment within 60 months or 400 flight hours whichever comes first.

ATSB assessment of action

The ATSB is satisfied that the manufacturer's beta lockout system service bulletin, when mandated by Transport Canada and implemented, will address the propeller system design issue.

QantasLink

Beta warning horn awareness

Minor safety issue

The operator's DHC-8 pilots had not had the beta warning horn demonstrated to them during their training. A similar situation applied to other Australian operators.

Action taken by the operator

The operator has introduced a detailed initial and recurrent training program on the beta warning horn to provide exposure to the sound to its pilots.

Other actions taken by the aircraft operator

- The operator delivered a Flight Operations Airworthiness Bulletin to all its flight crew that introduced a policy on hand position relative to the flight idle gate triggers.
- The operator conducted a risk analysis to confirm appropriate controls had been implemented to prevent future events of power levers being placed below flight idle in flight.
- The operator has issued a Flight Training Standing Order to all training organisation staff to be vigilant during training/checking events about hand position in relation to the flight idle gate release triggers.
- Following a review of modification options for in-flight beta protection, the operator decided to introduce the beta lockout system modification to all fleet aircraft. The decision was made before the manufacturer introduced a pending requirement to fit the beta lockout system to all aircraft worldwide.

Australian Transport Safety Bureau

The ATSB provided assistance to the Papua New Guinea Accident Investigation Commission during the DHC-8 accident on-site investigation. Following the on-site phase on 30 November 2011, the ATSB provided the Civil Aviation Safety Authority (CASA) of Australia with a briefing covering details of the investigation and the safety issues involved.

On 20 March 2012, the ATSB also provided a briefing to CASA regarding the VH-SBV investigation, the identification of the two other incidents in Australia and the several other related occurrences overseas. The ATSB advised CASA of the safety issue associated with the design of the DHC-8's propeller system that affected a considerable number of aircraft operating in Australia.

In addition to briefing CASA, the ATSB corresponded with the other main operators of the DHC-8-100, -200 and -300 series aircraft and provided explanations of the VH-SBV occurrence and related occurrences and a copy of the cockpit voice recorder (CVR) extract with the recording of the beta warning horn and the propeller overspeed to raise operator awareness of the occurrence and the safety issue.

The CVR extract was released under section 51 (1) of the *Transport Safety Investigation Act 2003* in the interest of transport safety, after the ATSB obtained the agreement of the crew and the operator involved. The CVR extract did not contain a recording of the pilots' voices or any personal information.

In the interests of transport safety, a copy of the CVR extract was also placed on the ATSB web site concurrent with the public release of this report.[12]

12 See www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-159.aspx

APPENDIX A: OCCURRENCES INVOLVING OTHER AIRCRAFT TYPES

Since about 1987, other transport-category turboprop aircraft types, equipped with similar engines and propeller systems, have been involved in propeller overspeed events, some of which led to loss of control of the aircraft. To date, all of the manufacturers of aircraft listed below have issued mandatory service bulletins or incorporated modifications to prevent ground beta activation during flight. The more significant events are summarised below.

Empresa Brasileira de Aeronáutica S.A. EMB-120

The EMB-120 is a twin turboprop aircraft with the same type of engine and propeller system to that of the DHC-8 aircraft. The EMB-120 aircraft type had seven propeller overspeed events up until 1989 that related to the inadvertent or intentional selection of below flight idle in flight.

The aircraft manufacturer designed the fitment of a flight idle lockout solenoid in 1990 as a propeller overspeed prevention strategy. The lockout solenoid was a mechanical means of preventing the selection of below flight idle in flight. The modification was mandated by a US Federal Aviation Administration (FAA) airworthiness directive (AD) 9017-12, and the modifications were applied to aircraft in other countries including Australia.

Since the installation of the lockout solenoid there has been only one other reported propeller overspeed event in 1992 that related to below flight idle selection in flight. In that event the flight idle lockout system malfunctioned.

Fokker F27 MK 50 (Fokker 50)

The Fokker 50 is a twin turboprop aircraft with the same type of engine but a different propeller system to that of the DHC-8. However, the engine and propeller system operated in a similar manner to the DHC-8 when below flight idle is selected in flight on the power levers.

The Fokker 50 has a device that prevents the selection of the power levers below flight idle in flight. However, on two occasions the flight idle lockout system malfunctioned causing accidents with multiple fatalities. Following the second accident in February 2004, the flight idle lockout system was modified and no further incidents or accidents have been reported.

Construcciones Aeronáuticas S.A. (CASA) C-212

The C212 is a twin turboprop aircraft with a different engine and propeller system to that of the DHC-8. However, the engine and propeller system operated in a similar manner to that of the DHC-8 when below flight idle is selected in flight on the power levers.

The C-212 aircraft initially did not have a system to prevent the power levers being moved below the flight idle gate in flight. Following an accident in 1987, the manufacturer designed and installed a mechanical lockout to prevent such events, and the lockout was mandated by the FAA by AD 91-03-10.

The aircraft had a mechanical lockout fitted when a second accident occurred in 1992, however the device malfunctioned. Following that accident, the manufacturer introduced a requirement to functionally check the lockout system on regular intervals. There have been no other events recorded since that time.

S.A.A.B. Aircraft Corporation 340 (Saab 340)

The Saab 340 is a twin turboprop aircraft with a different engine and propeller system to that of the DHC-8 aircraft; however, the engine and propeller system operated in a similar manner to that of the DHC-8 when the power levers were moved below flight idle in flight.

The Saab 340 had one accident in 1994 that related to intentional selection of below flight idle in flight that lead to a double propeller overspeed accident. The US National Transportation Safety Board (NTSB) report AAR-94-04 stated:

> …several serious incidents and accidents have occurred in the past that involved tupbopropeller airplanes in which the propellers were moved into the beta range in flight. The causes of these occurrences involved several factors. In some cases, wear and poor maintenance of the triggers and flight idle stops allowed inadvertent movement of the power levers into beta. In other cases, intentional movement of the power levers into beta was involved. Lastly, there have been cases of inadvertent movement of the power levers into beta with a properly maintained and certified system.

Following this accident, the aircraft manufacturer designed a mechanical means to prevent the selection of the power levers below flight idle in flight. The installation was mandated in the US by the FAA AD 96-18-03, and the modifications were applied to aircraft in other countries including Australia. No other Saab 340 accidents relating to below flight idle in flight have been reported since the modification.

APPENDIX B: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

- cockpit voice recorder
- flight data recorder
- flight crew of VH-SBV
- aircraft operator of VH-SBV
- flight crew of Australian DHC-8-102 event
- aircraft operator of Australian DHC-8-102 event
- aircraft manufacturer
- Transport Canada (TC)
- Transportation Safety Board of Canada (TSB)
- Australian Civil Aviation Safety Authority (CASA)
- Papua New Guinea Accident Investigation Commission (AIC)
- Papua New Guinea Civil Aviation Safety Authority.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the first officer and captain of VH-SBV, the aircraft operator, the aircraft manufacturer, CASA, TSB and TC.

Submissions were received from the first officer, aircraft operator, the aircraft manufacturer, TC, the TSB and CASA. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

24 Hours 1800 020 616
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
Double propeller overspeed involving Bombardier DHC-8, VH-SBV near Weipa, Queensland, 6 December 2011
AO-2011-159
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